**Temperature Sensor Testing**

For RLP-VLSI Research at UVA

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**Overview:**

Body Sensor Networks, a project of RLP-VLSI, has a task of developing custom temperature sensors that operate at low voltage. The current task is to get data, specifically power consumption and temp accuracy, from the commercial temp sensors and compare to the custom temp sensors that are developed. To do that we need a criteria on which temp sensors to buy, what adaptor boards would work for them, and a development board that can record the sensor’s data.

Most, if not all materials will come from Mouser.com or Digikey.com.

**Walkthrough**

1. **Getting Materials**
   1. **Temp Sensors**

* Different commercial Temp Sensors that could be purchased on sites such as **DigiKey** and **Mouser**
* Keyword constraints that were used while searching:
  + **Board Mount Temperature Sensors**
  + Output type: **Digital**
  + Digital Output: **3-wire, Microwire, SPI** (I2C not recommended, because it uses more power)
* How do you choose a good temp sensor?
  + Our first priority is to make sure the **VOH** is not greater than the **Max Input Voltage of the Dev Board** of your choosing.
  + Second priority is looking for a **low Quiescent (Leakage) Current**, **Power Supply Current**, and **Shutdown Current**. This can be found in the data sheets of each TS, though most likely you will only be able to find one of these parameters.
  + Other important factors are **Resolution** and **Accuracy**
* Figure 1 below is a list of how I organized the Temp Sensors that I was interested in based on their characteristics.

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| ***Description (and product link)*** | ***Mouser Part #*** | ***Mfr. Part #*** | ***Package Type***  ***(Adapt boards)*** | ***Accuracy ( C)*** | ***Resolution*** | ***Power Supply Current (uA)*** | ***Q-Current (uA)*** | ***Shutdown current (uA)*** | ***VOH (max 3.75V\*)*** |
| [*Board Mount Temperature Sensors SPI/3-Wire Digital Temp Sensor*](https://www.mouser.com/Search/ProductDetail.aspx?R=MAX31723MUA%2bTvirtualkey66880000virtualkey700-MAX31723MUA%2bT) | *700-MAX31723MUA+T* | *MAX31723MUA+T* | *uMAX-8 (same as MSOP-8)* | *0.5* | *9-12bit* | *1200M, actually doing something* | *1M* | *2M* | *VDD-0.4(min)* |
| [*Board Mount Temperature Sensors SPI/10-Bit plus Sign Digital Temp Sensor*](https://www.mouser.com/Search/ProductDetail.aspx?R=LM70CIMM-3%2fNOPBvirtualkey59500000virtualkey926-LM70CIMM-3%2fNOPB) | *926-LM70CIMM-3/NOPB* | *LM70CIMM-3/NOPB* | *MSOP-8 (0.65 mm pitch)* | *0.25* | *11bit* | *260T, 490M* |  | *12T* | *VDD+0.3(max)* |
| [*Board Mount Temperature Sensors 10-BIT DIGITAL IC*](https://www.mouser.com/Search/ProductDetail.aspx?R=AD7814ARTZ-REEL7virtualkey58430000virtualkey584-AD7814ARTZ-R7) | *584-AD7814ARTZ-R7* | *AD7814ARTZ-REEL7* | *SOT-23-6 (0.95mm pitch)* | *2* | *10bit* | *400M, 250T* |  | *.43T, 1M (V=3)* | *VDD-0.3(min)* |
| [*Board Mount Temperature Sensors High-Accuracy 10-bit*](https://www.mouser.com/Search/ProductDetail.aspx?R=TC72-3.3MUAvirtualkey57940000virtualkey579-TC72-3.3MUA) | *579-TC72-3.3MUA* | *TC72-3.3MUA* | *MSOP-8 (0.65 mm pitch)* | *2* | *10bit* | *400M, 250T* |  | *.1T,1M* | *0.7VDD (min)* |
| [*Board Mount Temperature Sensors 10bit digital temp sensor IC*](https://www.mouser.com/Search/ProductDetail.aspx?R=AD7314ARMZ-REEL7virtualkey58430000virtualkey584-AD7314ARMZ-R7) | *584-AD7314ARMZ-R7* | *AD7314ARMZ-REEL7* | *MSOP-8 (0.65 mm pitch)* | *2* | *10bit* | *Normal Mode (inactive): 300M, 250T, (active) 1000T* |  | *1M* | *2.4(min)* |
| [*Board Mount Temperature Sensors 1.5C Accurate Dig w/SPI Interface*](https://www.mouser.com/Search/ProductDetail.aspx?R=TMP121AIDBVRvirtualkey59500000virtualkey595-TMP121AIDBVR) | *595-TMP121AIDBVR* | *TMP121AIDBVR* | *SOT-23-6 (0.95mm pitch)* | *1.5* | *12bit* |  | *(TMP121) 35T, 50M* | *.1T, 1M* | *VDD-0.4(min)* |
| [*Board Mount Temperature Sensors Digital Temp Sensor*](https://www.mouser.com/Search/ProductDetail.aspx?R=LM74CIM-3%2fNOPBvirtualkey59500000virtualkey926-LM74CIM-3%2fNOPB) | *926-LM74CIM-3/NOPB* | *LM74CIM-3/NOPB* | *SOIC-8 (1.27mm pitch)* | *1.25* | *13bit* |  | *(LM74CIM) 265T, 470M* |  | *VDD+0.3(Max)* |
| [*Board Mount Temperature Sensors Digital Thermometer & Thermostat*](https://www.mouser.com/Search/ProductDetail.aspx?R=DS1722S%2bvirtualkey66880000virtualkey700-DS1722S) | *700-DS1722S* | *DS1722S+* | *SOIC-8 Narrow (1.27mm pitch)* | *2* | *8bit* | *500M* |  | *.5M (or 1M if V>3.3)* | *0.7VDD(min)* |
| [*Board Mount Temperature Sensors 2 DegC Accurate Dig w/SPI Interface*](https://www.mouser.com/Search/ProductDetail.aspx?R=TMP125AIDBVRvirtualkey59500000virtualkey595-TMP125AIDBVR) | *595-TMP125AIDBVR* | *TMP125AIDBVR* | *SOT-23-6 (0.95mm pitch)* | *2* | *10bit* |  | *36T,50M (at T=25C)* | *0.1T,1M* | *VDD-0.4(min)* |

*Figure 1- Temperature Sensors*

*\*3.75V was the max input voltage for our development board*

* 1. **Adaptor Boards**
* In order to test the sensors easily, they will need to be soldered to adaptor boards.
* Make sure the **pitch** (width between the connection pads) is not too big for the sensor you solder it to. Most likely the adaptor datasheets will give the pitch and specify what type of sensor they support.

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| --- | --- | --- | --- |
| **Description (and product link)** | **Mouser Part #** | **Mfr. Part #** | **Package Type** |
| [PCBs & Breadboards SOT 23/SC70 SMT to DIP Adapter](https://www.mouser.com/Search/ProductDetail.aspx?R=204-0003-01virtualkey59320000virtualkey872-204-0003-01) | 872-204-0003-01 | 204-0003-01 | SOT-23-6 |
| [PCBs & Breadboards 1.27mm Pitch SOIC to DIP adapter](https://www.mouser.com/Search/ProductDetail.aspx?R=204-0004-01virtualkey59320000virtualkey872-204-0004-01) | 872-204-0004-01 | 204-0004-01 | SOIC-8 |
| [PCBs & Breadboards .65mm Pitch SOIC to DIP Adapter](https://www.mouser.com/Search/ProductDetail.aspx?R=204-0006-01virtualkey59320000virtualkey872-204-0006-01) | 872-204-0006-01 | 204-0006-01 | MSOP-8 and uMax-8 (0.65mm pitch) |

*Figure 2- Adaptor Boards*

* 1. **Development Board**
* Since we would like to work with low voltage, the development board chosen is the **MachXO2-1200ZE-P1-EVN**

|  |  |  |
| --- | --- | --- |
| **Description (and product link)** | **Mouser Part #** | **Mfr. Part #** |
| [Programmable Logic IC Development Tools MachXO2 Pico Dev Kit](https://www.mouser.com/Search/ProductDetail.aspx?R=LCMXO2-1200ZE-P1-EVNvirtualkey55850000virtualkey842-LCMO21200ZEP1EVN) | 842-LCMO21200ZEP1EVN | LCMXO2-1200ZE-P1-EVN |

*Figure 3- Development Board*

* It is recommended that the **Lattice Diamond Software** should be downloaded to program the dev board
  + <http://www.latticesemi.com/Products/DesignSoftwareAndIP/FPGAandLDS/LatticeDiamond.aspx>

**Helpful sites for quick testing the board**

* Lattice Diamond and MachXO2 Breakout Board Tutorial
  + <http://eewiki.net/display/LOGIC/Lattice+Diamond+and+MachXO2+Breakout+Board+Tutorial>
* MachX02 Information
  + <http://media.digikey.com/pdf/Data%20Sheets/Lattice%20PDFs/MachXO2_Fam_Handbook_2013.pdf>
  + <http://www.latticesemi.com/en/Products/DevelopmentBoardsAndKits/MachXO2PicoDevelopmentKit.aspx>
  1. **Other Materials**
* Level conversion will need to be performed to connect the temp sensor to the dev board, and that can be done with passive devices and opamps. Below are devices that can help.

|  |  |  |
| --- | --- | --- |
| **Description (and product link)** | **Mouser Part #** | **Mfr. Part #** |
| 1kOhm resistors | 594-5083NW1K000J | PR02000201001JR500 |
| 100 Ohm resistors | 71-CCF60-100-E3 | CCF60100RFKE36 |
| 1MOhm resistors | 594-VR37000001004FR5 | VR37000001004FR500 |
| 0.1uF caps | 140-50U5-104M-RC | 140-50U5-104M-RC |
| 1uF caps | 667-EEU-FC1H1R0 | EEU-FC1H1R0 |
| 100uF caps | 667-EEU-EB1H100S | EEU-EB1H100S |
| Op-amps | 926-LMH6655MM/NOPB | LMH6655MM/NOPB |

*Figure 4- Level Conversion materials*

**Next Steps**

* To create a level converter from about 3.5V to 1.75V (check characteristics of Dev board and sensor to know exactly what you need)
* Test each chip and record the power consumption and temperature accuracy